

RÖNTGEN THERAPY

(21)



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THE
THERAPEUTICS OF THE
RÖNTGEN RAYS

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THE THERAPEUTICS OF THE RÖNTGEN RAYS

I

HYPERTRICHOSIS

THE introduction of the Röntgen rays into the province of dermatology has brought with it most important physiological and therapeutic advances in the treatment of diseases of the skin.

On the one hand, the accidental shedding of the hair after exposure to the Röntgen rays led to its use in cases where we wish to cause a temporary or permanent alopecia. On the other hand, its favourable effect in cases of lupus demonstrated its influence on the finer molecular transformations, and led to its use in other destructive diseases of the skin, not necessarily accompanied by loss of hair.

Many authors attribute its influence on this second class of cases to a bactericidal property. Its favourable influence on parasitic diseases, such as favus and herpes tonsurans, give colour to this opinion; but to this question we shall return later on.

At all events, it is certain that the X rays have an extraordinarily favourable influence on lupus vulgaris, lupus erythematosus, and certain forms of eczema. In addition, they have proved useful in hypertrichosis, sycosis, favus, herpes tonsurans, folliculitis, furunculosis, and certain forms of artificially-induced eczema.

To Freund must be accorded the priority in the use of the X rays in dermatology, since he was the first to produce an artificial alopecia in a case of hirsutes.

The case—that of a girl of five years of age—was under my

6 The Therapeutics of the Röntgen Rays

care. It was a *nævus pigmentosus pilosus*, extending over the whole of the back, which was thickly covered with hair.

It was a very unfavourable one, for it had been long treated by the usual methods without result. Freund undertook an experiment with the X rays, and this treatment I watched carefully during its entire course.

He began by exposing the back to the rays for a period of two hours each day. To our astonishment, after twelve days the hair began to fall out in thick tufts, and in a few days more the exposed part became perfectly bare.

This was the first case of a true scientific cure carried out by the Röntgen rays. Unfortunately, in consequence of too long exposures, a violent dermatitis was set up over a well-defined area. This healed very slowly.

This accident, however, was full of instruction. It warned us to take precautions against such unfortunate accidents in the future, to avoid prolonged exposures, and to produce epilation safely by an exact adjustment of the dose of this new physical agent.

In consequence of this experiment, we now give more numerous but less intense exposures. We use a current in the primary circuit of at most two ampères, with a potential of twelve volts. The distance of the tube is from six to eight inches. Each exposure is of only ten minutes' duration. By this means we get very satisfactory results, without any complications.

By a preliminary exposure we can make sure that there is no idiosyncrasy, causing the skin to react too quickly or too strongly to the Röntgen rays. For this purpose, for one or two preliminary sittings, we expose the patient for fifteen minutes at a distance of eight inches to rays of moderate intensity, this being the least dose which can cause dermatitis.

We then keep the patient under observation for some time. If a reaction appears, we know that the dose must be still further diminished, and we can then proceed without interruption in the further treatment and without fear of complications.

The results we have obtained in this manner are extraordinarily satisfactory. We cannot, however, hide from ourselves that they are still far from that ideal degree of perfection for which we strive.

Jutassy* followed the method devised by Freund and myself,

* *Orvosi Hetilap*, 1898, 21-28.

and like ourselves was able by these means to produce a destruction of the hair papilla.

In epilation by means of the X rays, Jutassy describes four stages.

1. Stadium cumulationis—stage of exposure.

2. Stadium hyperæmicum, with redness coming on slowly. During this stage the hair may be shed, but the alopecia is only temporary.

3. Stadium inflammationis—stage of dermatitis, with hyperæmia, accompanied by slight transient erythema. This may go on to pustular dermatitis, with all the characteristic signs of inflammation, which is followed invariably by loss of hair.

4. Stadium regenerationis—stage of recurrence. This will usually occur after a period of two or three months, but only in those cases where the treatment has been insufficient. The absence of this recurrence of hair after three months' interval is a sign that the action of the rays has been sufficient, and the prognosis of a permanent alopecia may be assured.

Oudin and Barthelemy* have come to an opposite conclusion, as the result of a series of experiments on epilation. This is in direct opposition to our experience and that of other observers in Germany, England, and America.

A previous series of experiments on animals gave but unsatisfactory results.

Two series of observations were made on the human subject, and the part chosen for experiment was the regio pubica of women, the hair differing considerably in tint, colour, and thickness.

In the first series frequent short exposures were used; in the second series, a single exposure of long duration.

In the first series—of ten minutes' duration—the exposures were repeated daily, or every other day, for a period of from two to four weeks.

Two cases were without result; the third was followed by slight erythema and partial shedding of hair.

In the second series intense exposures of ten to thirty minutes were used at a distance of six inches. The results were negative in three cases. In three cases there was a slight loss of hair, and the hair came out easily with combing or slight traction. Only in two cases was there a total epilation, one of these being accompanied by a widespread erythema.

* *La Radiographie*, 1900, No. 39.

Gocht* reports the treatment of a *nævus pigmentosus piliferus* in a child of three years of age. The results followed daily intense exposures for fourteen days. Then reaction set in suddenly, with redness, blistering, excoriation, and the shedding of the hair. This occurred only in the abnormal tissue in the neighbourhood of the *nævus*.

In May, 1898, in collaboration with Freund,† I reported a series of seven cases of epilation.

We showed that the length of exposure was the principal factor determining the degree of reaction, that long exposures were very dangerous to the skin, while short exposures were completely successful in causing epilation.

Unfortunately, it is extremely difficult to adjust the strength of the Röntgen rays, or to estimate the dose accurately.

This latter depends on the strength of the primary current, the frequency of the interruptions, the suddenness of the interruptions, and the degree of exhaustion of the tube. Moreover, the intensity and quality of the X rays depend on other unknown factors and events occurring in the tube, so that it is impossible in the present state of our knowledge to give the intensity of the X rays in absolute measure.

A rough approximation may be obtained, however, by aid of the fluorescent screen, and the relative intensity of the rays may be estimated by observing the distance at which the bones of the hand are clearly differentiated from the soft parts. The greater this distance the more intense are the rays.

Under these conditions an occasional slight erythema is the sole visible result of the treatment, so that patients are apt to become very sceptical of its success.

Shortly before the hair begins to fall out the skin frequently becomes brown. The accumulation of pigment increases until the hair falls out, and then rapidly disappears in the course of three or four days. Shortly before it is shed the hair itself becomes snow-white.

In one case this phenomenon was repeated a second and third time, when the recurring black hairs were again submitted to the action of the rays.

Our experiences in this respect have been confirmed by Sjögren,‡ who observed a rapidly-disappearing pigmentation in the case of a brunette of twenty-five years of age.

* *Fortschritte*, Bd. I., S. 17.

† *Wiener med. Wochenschrift*, 1898, No. 22.

‡ *Bibliotheca medica*, Heft 8. Dr. Möller.

Another interesting effect is the following: During the treatment all roughness and unevenness of the skin disappears, together with the scar-pits resulting from previous folliculitis. The skin becomes smooth and without blemish, with a corresponding improvement of the complexion. In certain cases, however, a few flat, colourless depressions make their appearance, somewhat similar to those seen after treatment by electrolysis.

The fact that the hair is shed only after a long series of exposures proves conclusively that the X rays have a cumulative action. This view of the cumulative action of the Röntgen rays has been confirmed by Forster.*

Grumnach† has made experiments on epilation, but with varying success, since in some cases the hair returned after a time.

These unsatisfactory results are due to the absence of the necessary precautions. I have insisted again and again on the necessity of a short after-treatment in order to get durable results.

Let us now turn to the question of what advantages radio-therapy has over other methods in the treatment of hypertrichosis, now that the one great disadvantage of radio-therapy, namely, the risk of dermatitis, has been entirely eliminated.

An objection brought against the treatment of hypertrichosis by X rays has been the supposed short duration of its effect. On the contrary, we may now claim for radio-therapy that it is the only radical treatment for hypertrichosis, even when compared with electrolysis.

When we consider the difficulty and long duration of the treatment of an extensive hypertrichosis, its serious physical, mental, and even moral, results, and the scars remaining after the treatment, we might well welcome this new, rapid, painless, widely-reaching cure, even if its results were only of two or three months' duration. Moreover, we may ask: Is the result obtained by electrolysis always a durable one? Giovannini has made very exact observations on this point. He found that in 50 per cent. of the operations the needle did not penetrate the hair sheath. But in our opinion the destruction of the hair is not always attained even if the hair papilla has been directly attacked.

The current is, as we know, led to the point of the needle,

* *Wiener klin. Wochenschrift*, 1897, No. 3.

† *Deut. med. Wochenschrift*, 1899.

which has been introduced into the skin. There it acts as a kathode, and sets up a chemical decomposition in the neighbouring tissue. The current passes along the path of least resistance, which will not always be that from the papilla to the needle-point, but more often at the spot where the needle first comes into contact with the surrounding tissue or its fluids. This spot will be found somewhere in the shaft of the needle, and not at its point. We do not get a special localized action taking place solely at the point of the needle.

The result of electrolysis is therefore uncertain. Relapses after electrolysis have been frequently reported of late. Besnier and Brocq report that electrolysis gives good results only in very skilful hands, and that otherwise permanent scars may result.

According to Brocq, a treatment of two years is necessary in order completely to remove a beard. Six months is required for the upper lip or chin, and even then a favourable result is not certain.

On the other hand, as regards epilation by the X rays, we have at length been able to render it permanent.

The phenomena due to the separation of the hair bulb from the hair papilla have been studied by Kaposi in their clinical aspect, and confirmed by the anatomical investigations of A. Kibbe of New York.* If we can maintain this solution of continuity for some months, it is probable that the hair papilla will never regain its normal function.

In support of this hypothesis, Freund adduced the following facts with regard to favus. This disease is caused by certain fungi growing in the sheath of the hair root. The pressure on the papilla thus exerted causes a disturbance of its nutrition which, if long continued, results in ultimate wasting and consequent baldness. Our object, then, must be to maintain for a considerable period that alteration in the nutrition and function of the papilla primarily produced by the X rays. For this purpose we give the patient a second series of a few short exposures. This we do just before the time when we know by experience that the primary influence on the papilla will have ceased, and consequently new hairs will begin to grow. This occurs usually from two to three months after the first series of exposures.

As far as results are concerned, it is immaterial whether the disturbance in nutrition is due to a mechanical pressure or to a

* *New York Journal of Medicine*, January, 1897.

paresis of the bloodvessels. We may therefore hope, by setting up a condition similar to that present in favus, to be able to cause a similar loss of function in the hair papilla. We do not indeed regard the X rays as having any selective action on the hair papilla. Such an hypothesis is quite unnecessary. The alteration of the hair papilla has a visible result—*i.e.*, the shedding of the hair—whereas the X rays have no visible or functional effect on the interstitial tissues.

It has been proved that only a very slight stimulation is necessary to maintain the degeneration of the altered papilla. It is therefore evident that the X rays are of utility not only in hypertrichosis, but wherever it is desired to produce a complete and permanent destruction of hair.

In favus, sycosis and other inflammatory and parasitic diseases of the hairy parts of the skin there is no treatment so prompt and radical as radio-therapy, and that without the aid of any other external or internal treatment. In a few weeks the most chronic and obstinate cases are completely cured.

The object we had in view when we first undertook the treatment of these dermatoses was simply the destruction of the hair, which we regarded as a foreign body keeping up inflammatory processes in the follicle. By its removal we endeavoured to eliminate the irritation of the papilla and of the interfollicular tissue.

In sycosis, after the shedding of the hair, no new pustules appeared, and secretion and scab-formation ceased; but we made the interesting discovery that even before the shedding of the hair there was a noticeable diminution of the inflammatory processes and that the more striking inflammatory infiltrations in the surrounding tissue disappeared.

In this stage the extracted hairs were dry and without any bulbous swelling at the root, whereas before the treatment they appeared surrounded by a glassy root-sheath.

At the same time all sensation of swelling and heat disappeared.

In favus the treatment was more energetic, the whole hairy scalp being exposed to the ray, and the treatment continued until it was completely epilated.

This was done in order that no parasitic focus might remain to set up a reinfection.

In all cases we were able to avoid the occurrence of dermatitis. On the appearance of any redness which differed in character

from that of the general hyperæmia, the treatment was stopped. After seven to eleven sittings the hair became loose and fell out spontaneously or with slight traction. The redness and all other appearances of the disease disappeared in the course of the next ten or twelve days.

It is thus certain that the X rays have a favourable influence on sycosis quite apart from the effect due to the destruction of the hair. In no other way could we explain the amelioration after four or five sittings before a single hair had been shed. The diseased, moist, pus-soaked skin became drier, the pustules and inflamed follicles dried up and disappeared, and the itching ceased.

It is not to be wondered at that the long-persisting alopecia caused by the X rays should be efficacious when we reflect on the improvement following the temporary and irritating epilation by the ordinary method by means of forceps.

Kaposi* makes the following objection: 'If we assume that a sycosis may be produced by irritation due to an anomaly of the hair, then after epilation the sycosis should return with the renewed growth of hair. Some such thing does, indeed, happen in cases of favus. The hairs themselves are shed, but the root-sheaths are still full of fungus, and frequently new foci of disease are thus formed.

With regard to favus, Kaposi's objections are not valid. All my cases treated by the X rays have remained permanently cured; no return of the disease can be observed either clinically or by microscopic examination.

It is doubtful, however, whether this favourable result is due exclusively to the Röntgen rays or to the action of the carbolic ointment which we apply after the completion of the epilation.

In sycosis the result is somewhat different, the affection returning in certain cases after from two to four months. This, however, cannot be due entirely to the irritation of the returning hairs, for the mechanical irritation should return as soon as the hairs begin to grow. This was not the case, since in all our cases the hairs returned in about fourteen days and a perfectly normal beard appeared, the skin still remaining healthy for some time.

At the Congress at Hamburg we showed a number of cases, with magnificent beards, in which no relapse had occurred. In some instances, however, there was a return of the disease. In

* *Sitzung der dermatolog. Gesellschaft, Mai, 1899.*

one case a local sycosis broke out in the back of the head, which had hitherto been perfectly healthy and had not been exposed to the rays. This last was cured after four or five sittings without the hair becoming loosened or falling out.

If anomalies of growth were the cause of the disease, these few exposures, which were quite insufficient to produce epilation, would have been of little use. Some other more general cause must have been present to account for the secondary outbreak of sycosis in this case.

Albers-Schönberg* promptly procured epilation in a case of favus. The skin after the treatment was soft and sound with normal growth of hair.

Kienböck has recently treated cases of alopecia areata by radio-therapy with success.

It is doubtful how far the rays are to be regarded as the inciting cause in these cases. I must however repeat what I said at the debate on pelade at the Paris Congress—namely that considering the magnificent results obtained in favus, we may expect that Röntgen therapy will be found useful in all cases of alopecia.

Gassmann† and Schenkel treated with the X rays a case of sycosis non parasitaria, seu folliculitis atrophicans serpiginosa barbæ, answering probably to the acne pilaire of Besnier or the ulerythema sycosiforme of Unna.

The disease was of thirteen years' duration. After nine exposures redness and swelling set in, and the treatment was stopped. All appearance of folliculitis disappeared, the skin remaining bald and normal. Seven months later the skin was unaltered, being still bare and sound. Whether this result was due solely to the destruction of the hair is doubtful, as nothing is definitely known as to the cause of this disease.

Hahn's‡ sycosis parasitaria heals promptly under this treatment. After a few exposures, the swellings of the size of a walnut disappeared, the hair was shed, and the inflammation ceased. After the slight excoriation caused by the rays had abated, the disease disappeared.

Favourable results occurred in several cases of sycosis non parasitaria of from two to twenty years' duration. A case was exhibited where the affection had continued for six years. On

* *Ärzte Verein*, Hamburg, 1898.

† *Fortschritte*, Bd. II., Heft 4.

‡ *Ärzte Verein*, Hamburg, 1900. Autoreferat.

both cheeks, on the chin, and on the upper lip, the hairs remained sticking out of the inflamed follicles, the intervening skin being red and infiltrated. After twenty-three exposures a dermatitis with slight excoriation of the skin set in, which interrupted the treatment. The chin and cheeks were smooth and normal, whilst the upper lip remained slightly red.

Pochitonowa* reports marvellous success in acne and herpes tonsurans. Grouven† has had good results with hypertrichosis and sycosis, but negative results with favus.

The question whether relapses may be definitely obviated is of decisive importance for the future of epilation by means of Röntgen rays. Is the treatment able to destroy the energy of the hair bulb for ever? To this question, after observations extending over more than three years, I can with full assurance answer Yes.

II

LUPUS

HOWEVER much dermatologists may differ as to the efficacy of the X rays in epilation, they are all agreed as to its utility in the treatment of lupus.

We have already pointed out that in the treatment of hypertrichosis dermatitis may be set up by too long and too intense exposures, and this dermatitis may take on a necrotic character. The facility with which the X rays set up inflammation and destruction of the tissues in the deeper layers of the skin first led me, in the year 1897, to use them in the treatment of lupus.

I need not enter now into the much-debated question of priority of the use of X rays in therapeutics. The discovery due to the genius of Röntgen naturally led up to its use in diagnostics and therapeutics. I must however claim for Freund and myself its introduction into dermatology—the development of an exact system—and the origination of a definite method for this new system. Indeed, in the report of my first two cases—published in the *Archiv für Dermatologie und Syphilis*, Bd. XLII.—I gave

* Twelfth International Medical Congress.

† Bonn Niederrhein. Gesellschaft für Natur-und Heilkunde, Fortschritte, Bd. IV., Heft 2.

a detailed account of the favourable influence of the inflammation set up by the X rays in cases of lupus. These had a selective action on the lupus nodules themselves, which in process of time fell out, and were replaced by healthy scar tissue. My deductions from these two cases were the following:

1. General inflammatory action.
2. Specific reaction of the lupus tissue to the X rays, so that the lupus nodules, hitherto imperceptible, became visible.
3. Loosening and shedding of the nodules.
4. Swelling of infiltrated lymphatic glands in the neighbourhood.
5. Alteration of the torpid ulceration into a healthy granulation tissue.

Thus the reaction set up by the X rays consists of a violent inflammation, beginning in the deeper layers of the skin.

In the treatment of hypertrichosis we stop the action of the X rays at a certain point—viz., the shedding of the hair—before any further alteration has set in.

In the treatment of lupus, on the other hand, we set up a violent inflammatory process in the deep layers of the skin. This however heals much more quickly than does the accidental dermatitis occurring in the course of epilation.

Happily, the X rays admit of an exact graduation of the dose, whereby we may cause a weaker or stronger reaction. We can produce epilation without dermatitis, or we can set up an inflammation, the degree of which is completely under our control.

The regulation of the dose consists of two parts—the strength of the X rays themselves, and the intensity of their application.

The strength of the rays is conditioned by the construction of the coil, the interrupter, and the vacuum tube, and by the strength of the primary current.

The intensity of application depends on the distance of the vacuum tube from the patient and on the duration of the exposure.

Our case-book keeps a record of the date, the number of the sitting, the area of exposure, the intensity of the X rays, the duration of exposure, the distance of the tube, and the strength of current in volts and ampères.

In epilation we are anxious to avoid all inflammatory reaction, and therefore make use of the less intense X rays, with a maximum of two ampères in the primary current, a potential of twelve volts, a distance of eight to ten inches, and a duration of

exposure of ten minutes only. If, on the other hand, we wish to set up an inflammatory process, we increase the current to three and a half ampères, and the potential to twelve volts, diminishing the distance to four inches. We do not, however, increase the duration of exposure. The surrounding skin should be protected by a suitably-modelled mask of lead.

In the lupus cases the reaction always runs the same course, the lupus nodules gradually becoming dark red and turgescient. Moreover, certain dark spots develop in places which previously appeared quite normal, and subsequently take on the character of lupus nodules. Later on the nodules drop out, leaving holes, which are well defined, as if punched out, and are about the size of a pin's head.

In our more recent cases, in consequence of the milder intensity of the X rays, the reaction was not so severe, the process of healing set in more rapidly, and the therapeutic effects were more satisfactory.

In the situation of the nodules there remained small, red, somewhat depressed scars, while the intervening skin appeared white and smooth.

Has this new therapeutic agent an assured future before it? Will it lead to a newer and better mode of treatment, or a definite shortening of the ordinary process of cure? Let us compare it with other modes of treatment.

The light treatment introduced to our notice by the genius of Finsen has results which correspond in a great measure to those of the Röntgen rays.

The simplicity of the Röntgen procedure compares favourably with the complexity of Finsen's light treatment. This latter gives, indeed, most excellent results, but is tedious, necessitating a number of assistants, and requiring expensive and complicated machinery. Moreover, the Röntgen rays can attack a large area of affected skin, whilst the light treatment can only influence a small spot at a time.

Here I would emphasize my opinion that Finsen's method is adapted more particularly to the treatment of small spots of lupus, whereas large patches are more successfully attacked by the X rays.

The advantages in the treatment of lupus by the X rays have been recently pointed out by Kümmel of Hamburg* and by Robert R. Mühsam. Its result is most noteworthy when we

* *Deut. Zeitschrift f. Chirurgie*, Bd. XLVII. 4.

consider the mildness and painlessness both of the procedure and of the reaction, and when we compare it with the excessive pain resulting from cauterization, excochleation, hot air, Paquelin's cautery, etc.; and when we further take into consideration the terror of extirpation, or any other operative procedure, exhibited by nervous patients. Moreover I have already proved that the X-ray treatment is followed by durable results.

My first published case was that of a girl of fourteen years of age, in whom a lupus patch on the back of the hand and on the outside of the forearm was permanently healed; whereas one occurring on the front of the same arm, which had been left untreated by the X rays, was not in any way influenced.

This may be explained by the fact that the bones probably shielded the latter patch from the action of the rays, which would otherwise have reached it through the substance of the arm.

In April, 1898, I exhibited this case to the K.K. Gesellschaft der Aerzte. The scars on the back of the hand and forearm were white, smooth, and normal, with no sign of recurrence; whereas on the front of the arm, which had not been exposed to the rays, the disease had increased in area, and had taken on an ulcerative character.

Extirpation is, however, in my opinion, the ideal treatment when we have to deal with circumscribed patches of lupus in an easily accessible position. It would be manifestly absurd to attack an isolated lupus nodule by a radio-therapy of some months' duration, when an equally favourable result might be obtained by extirpation in the course of a few days.

The cases particularly suitable for radio-therapy are those which are widely diffused, which are complicated by deep ulcerative processes, or which encroach on the mucous membrane or other situations not amenable to operation.

The mucous membranes of the lips and nose react promptly to the Röntgen rays. These give very favourable results after relatively short treatment, even when the affection of the mucous membrane has gone on to ulceration.

I have had good results in cases where operation has been impossible. The functions of the diseased organs have been restored, and there has been marked improvement in the appearance of the patient.

On the other hand, extirpation is a painful operation, necessitating the administration of an anæsthetic. Moreover, even extirpation does not give us absolute security against recurrence,

either on the site of operation or in other situations, which renders a second operation necessary. The effect of operation on the patient's appearance is frequently very unsatisfactory. The same may be said of Thiersch's method of epidermic transplantation, which is often followed by shrinking and distortion of the scars. This is also true of the operative methods originated by E. Lang, Urban, Gersuny and others.

The treatment by the X rays compares favourably with these methods in being bloodless and painless, and especially in its good results on the general appearance of the patient. It is true that when compared with extirpation, the X rays do not act with the same rapidity and precision. The local effect is however milder, leaving the sound tissue intact. The treatment is much less formidable to a nervous patient, since even residence in a hospital is unnecessary.

Let us now turn to the evidence of other observers. Gocht has reported six cases. In the first the result was negative, the diagnosis being uncertain, the disease being probably syphilitic* in character. In the remaining five cases, the results were very satisfactory. The following method was pursued by Gocht and Kimmel. Exposures of a quarter to half an hour's duration were repeated twice daily. The dose was increased every two days, and the sittings were only temporarily discontinued in consequence of more or less severe reaction of the skin. No other treatment was used except the occasional application of starch or simple compresses for ulcerations or moist granulations. The tube was brought as near the patient as possible—*i.e.*, to a distance of two and a half to two and three-quarter inches. Dermatitis and loss of hair occurred in the parts adjacent to the disease. To obviate this they used leaden masks three-quarters of a millimetre thick, to shield the neighbouring parts. The patient was placed on a couch which was insulated by means of glass feet, since they found that the treatment was materially shortened by this means.

The whole body of the patient becomes charged with electricity, although it does not come into contact with any electrified body. Electric sparks may be drawn from any part of the body, and this the more readily the nearer the tube is brought to the patient. They used tubes giving a light of medium intensity. The current was one of high potential, not less than fifty volts. No return of the disease occurred after the lapse of three to four months.

* *Therapeutische Verwendung der R. Strahlen. Fortschritte*, vol. i.

Kümmel of Hamburg* treated sixteen cases of lupus, in ten of which a cure was effected. In consequence of the shortness of the treatment, or for other reasons, the remaining six were without result. In every case the process of cure followed the same course. The cleansing of the ulcers was followed by the formation of a scab, the subsequent drying and shedding of the scab, desquamation of the skin, disappearance of the redness, and ultimate formation of a white scar without any shrinking of the tissue. The essential advantage of the treatment consists in the character of the scar, which is almost like normal skin in appearance. No other treatment gives such good results in this respect.

Albers Schönberg† reported a number of cases of lupus which at the date of publication were all either cured or greatly ameliorated. In his experience the treatment had no beneficial effect on lupus of the nasal mucous membrane. He lays great stress on the importance of so adjusting the intensity of the rays as not to set up acute dermatitis with consequent pustulation, and insists on the discontinuance of the treatment on the slightest appearance of reaction. In opposition to Gocht, he disapproves of the use of currents of high potential. Their action may, indeed, be more rapid, but often gives rise to untoward accidents. The same results are obtainable with weaker currents with greater safety to the patient, although at the expense of a somewhat longer duration of treatment.

In May, 1898, Neisser‡ showed three lupus cases treated by the X rays, of which two were much improved and one completely healed. Neisser considers the process to be due to a gradual encapsulation and subsequent breaking down of the tubercular new growth by the inflamed and hyperæmic tissue.

Gassmann and Schenkel§ give detailed reports of four cases of lupus thus treated. In none of these did they observe the mode of healing described by the foregoing investigators—viz., the shrinking of the nodules with cleansing and scarring of the lupus ulcers. In all their cases a sharply defined ulceration was set up, not only in the neighbourhood of the lupus patches, but also in the already cicatrized tissue. The healing of this ulcera-

* *Die Behandlung des Lupus mit R. Strahlen und mit Konzentriertem Licht.* XXVII. Kongress der d. Gesellschaft f. Chirurgie, Berlin, 1898. Under a reference to Albers Schönberg.

† *Fortschritte*, vol. i., p. 72.

‡ *Ibid.*, vol. ii., p. 114.

§ *Beitrag zur Behandlung der Hautkrankheiten mittels R. Strahlen.* *Fortschritte*, vol. ii., p. 121.

tion was very tedious. In two of these cases, treated respectively with fifty-seven and forty-one exposures, relapses occurred seven months after the conclusion of the treatment. These unsatisfactory results depended on the too short duration and insufficient intensity of the exposures.

Sonnenburg, Ziemssen, Holland, and Mühsam have treated dermatoses by this means, and have reported their experiences and exhibited typical cases in various medical societies. Most of them report satisfactory results; Sonnenburg alone is somewhat sceptical.

Recently Hahn* has begun to treat lupus with X rays. In the treatment of chronic isolated or circumscribed patches he makes use of Finsen's method, if the patient has the necessary time to devote to the treatment. If this is not the case, he uses electrolysis or Hollander's method, the latter more especially for disease of the mucous membrane. The results reported from the Röntgen Institute of Dr. Stenbek of Stockholm, and those of Dr. Sjögren, are also so far favourable.

III

LUPUS ERYTHEMATOSUS

THE noticeable influence of the X rays on the deeper tissues of the skin, on the hair papilla, on lupus nodules, on elastic tissue, and on the fibres of connective tissue (Unna), led me to undertake the treatment of diseases having their origin in the deeper layers of the corium. Such a disease is lupus erythematosus, which consists in an inflammatory process, leading to cell infiltration and cell aggregation in the dilated capillaries of the corium and the papilla.

My first case, published in the second volume of the *Fortschritte der Röntgen Strahlen*, was a typical one of lupus erythematosus of seven years' duration.

The method of treatment was identical with that employed in lupus vulgaris. The infiltration disappeared entirely in the area exposed to the rays; around it a ring of pigmentation formed,

* *Ärzte Verein*, Hamburg, 1900. Autoreferat, *Fortschritte*, vol. iv.

but this also disappeared after a short time, leaving the skin which had been exposed to the action of the rays perfectly flat and smooth, and almost normal in appearance.

In the treatment of lupus erythematosus I use new vacuum tubes giving a very intense light, a current of three and a half ampères, a potential of twelve and three-quarter volts, a distance of four inches, and a duration of from ten to fifteen minutes. The results are very favourable.

It is of great interest to notice that the X rays have the same beneficial action on two diseases so widely differentiated histologically as lupus vulgaris and lupus erythematosus. Kaposi, in the discussion on these cases, gave an explanation of this fact. He says: 'It is evident that the influence of the rays is due to an alteration of the vascular tone, which manifests itself clinically as an erythema or dermatitis. In this case, evidently, an erythema had been set up, as is proved by the pigmentation which was still visible around the irradiated cheek. I have also used this explanation to account for the epilation in my case of nævus pilosus of the back. In cases of insolation the superficial capillary vessels become paralyzed and hyperæmic. The X rays cause in addition paralysis and hyperæmia of the more deeply-seated vessels and of the hair papillæ. As a consequence, we get a raising and separation of the hair bulbs and the subsequent shedding of the hair. As a logical deduction from this explanation I prognosticated the recovery of this vascular tone with consequent regeneration of the epidermic tissue and the formation of a new hair cone, causing a fresh growth of hair. In every case my prognostication has been fulfilled, and the hair has reappeared.'

The action of the X rays is similar to that produced by hyperæmic and inflammatory processes set up by other agents, as, for instance, the tuberculin of Koch, or by the application of external irritants, such as iodine, which in certain cases will cause the disappearance of the infiltration of lupus vulgaris, as well as that of lupus erythematosus.

Taking into consideration the great difference between these two diseases, I cannot help thinking that an additional factor is necessary to account for the utility of the X rays. I consider that the rays have a deeper action on the cell elements of the inflammatory infiltration and the newly formed tissues, probably causing fatty degeneration or other molecular alterations, and thus facilitating their ultimate absorption.

The second case of lupus erythematosus treated by X rays was reported by Jutassy* in August, 1899. He succeeded in absorbing the infiltrated cells deposited between the capillaries of the corium and those of the corpus papillare. A partial recurrence of small extent only occurred in situations where the rays could not easily penetrate. Hahn and Grouven† also report successful treatment of lupus erythematosus.‡

IV

Eczema.—In the radio-therapy of chronic eczema, Hahn§ may claim the priority. He proceeds on the following considerations. If eczema can be traced to a bacterial cause, then, as shown by the researches of Rieder, we may expect the X rays to influence the bacteria themselves. If on the other hand, eczema be considered as a disturbance of the nutrition of the skin, then the action of the rays in causing dermatitis leads us to hope that the reaction of the tissues will cause alterations in the circulation and nutrition and consequent healing.

Hahn, in conjunction with Albers-Schönberg, has treated several cases of chronic eczema occurring on the legs and the back of the hands, and chronic impetiginous eczemas of the scalp. These were all completely healed.

The most interesting point was the rapidity of the improvement which set in after from ten to twelve exposures. The immediate effects were the cessation of secretion, the drying of the skin and desquamation.

At the Medical Congress at Hamburg in 1900, Hahn showed a girl, seventeen years of age, who from childhood had suffered from eczema of both hands. This had been completely cured by six exposures. In addition to the already well-established fact that eczema reacts to the X rays with peculiar rapidity, Hahn noticed a prompt disappearance of the accompanying irritation

* XXX Wanderversammlung ungar. Aerzte, 1899. *Fortschritte*, vol. iii., p. 118.

† *Aerzte Verein*, Hamburg, 1900.

‡ Niederrhein Gesellsch. für Natur-und Heilkunde in Bonn.

§ *Fortschritte*, vol. ii., p. 16.

and itching. Since that time Hohn, Ziemssen, Jutassy and myself have had most favourable results in chronic eczema.

Psoriasis.—Attempts to employ radio-therapy in the treatment of psoriasis have so far given positive results in the hands of Ziemssen and Albers-Schönberg. Jutassy* has also made experiments in this direction, of which the results are not yet complete. Hahn† has also reported its favourable influence on psoriasis patches. The scales fell off after from four to six exposures, without any appearance of the bleeding-points characteristic of psoriasis.

The lapse of time is still too short to speak positively on the question of recurrence in these cases. Grouven, in the Nieder-rheinische Gesellschaft at Bonn, has also reported favourable results.

Elephantiasis.—Sorel and Soret‡ report success in the treatment of elephantiasis.

Lepra.—Dr. de la Camp§ has not been so successful with lepra. He exposed the hands of a patient daily to the X rays for some time without any good results. He believes the failure to be due to reinfection from other parts of the body.

Malignant Growths.—Even in malignant growths radio-therapy seems to be of help, since Sjögren|| has reported one such case of epithelioma of the face. Stenbek¶ of Stockholm reports good results in cancer, in a deep epithelioma of the nose, and in a typical superficial epithelioma.

Nævus.—Jutassy may claim the priority in the application of Röntgen-therapy to diseases of the bloodvessels of the skin.

In 1897 he made the first experiment in a case of angioma teleangiectodes (nævus flammeus) in a man of twenty-two years of age.

The teleangiectosis affected the whole right half of the face, with considerable swelling.

Jutassy had come to the conclusion that the X rays themselves could produce an alteration in the deeper bloodvessels of the skin, and that, moreover, the dermatitis set up by the rays tends to the formation of a healthy scar tissue, more satisfactory in

* *Fortschritte*, vol. ii., p. 16.

† *Ärzte Verein*, Hamburg, 1900. IV. Bd., Autoreferat.

‡ *Société des Sciences*, 1898.

§ *Fortschritte*, vol. iv.

|| *Bibliotheca medica*, Heft 8. Congrès internat. d'Electrologie et de Radiologie médicale, 1900.

¶ *Fortschritte*, vol. ii., p. 216.

appearance than that obtained by any other form of artificial dermatitis.

The result was most surprisingly satisfactory. The nævus disappeared and no trace of angioma remained. A soft smooth scar, surrounded by a brownish-yellow zone of hyperpigmentation, replaced the diseased portion of the skin.

Acne Rosacea.—Jutassy was also the first to treat acne rosacea by the X rays.

According to my observations also, this disease is very favourably influenced by Röntgen-therapy.

Hahn* reports two cases of acne rosacea, in which he obtained satisfactory and durable results. The redness of the nose and of the neighbouring parts disappeared, and had not returned after an interval of several months.

Varicose Ulcers.—Colville† asserts that he has treated varicose ulcers successfully with X rays.

Acne Vulgaris.—It had been frequently noticed that acne vulgaris disappeared in cases where the skin had been treated for other diseases by the Röntgen rays; moreover, I had observed a marked improvement in the complexion, with total disappearance of comedones and inflammatory follicles after exposure to the rays. These observations greatly extended the range of diseases and pathological processes which are now submitted to treatment by Röntgen-therapy.

To recapitulate: both the theory and the technique of the Röntgen rays have made rapid progress during the last few years, and will undoubtedly make still greater advances as our experience in this field of work grows wider. The original energetic application of the rays to the skin was soon given up in consequence of the resulting complications. The action of the rays on the superficial layers of the skin was the first to attract attention. Short and weak exposures caused hyperæmia and erythema of the skin, whilst long, intense exposures set up a deeply-seated inflammatory process. This however does not occur at the moment of exposure. It is a secondary reaction, coming on after a longer or shorter interval as a result of the cumulative action of the rays.

The Röntgen dermatitis has a great resemblance to wounds caused by burning. It begins with deep ulcerations of the cutis, which easily become gangrenous and necrotic, heal with great

* *Aerzte Verein*, Hamburg, 1900.

† *L'union méd. du Nord-Est*, 1897.

difficulty, and have somewhat the appearance of torpid specific ulcers. It leaves behind it a smooth scar.

Gassmann and Schenkel* undertook the histological examination of this dermatitis. They found that the tissue was not necrotic in the ordinary acceptation of the term, but consisted of various characteristic, easily stained elements. The chief of these were bundles of collagen fibres of normal appearance, their nuclei being readily stained by the usual methods. Here and there were seen degenerate forms, like those found in pathologically altered tissue, which readily received nuclear stains. These were of peculiar aspect, some being drawn out into long threads, others much branched, indented, or grouped in irregular clusters. There were also a few large lymph-vessels and capillaries distended with blood. Elastic fibres were found in abundance, with here and there collections of crowded mononuclear leucocytes or a slight extravasation of blood. The adipose tissue was unaltered.

As yet Gassmann has not decided whether this peculiar tissue may be regarded as an altered subcutaneous tissue or as a newly-formed tissue already undergoing degeneration; in any case, it completely disappeared on the application of potash compresses. The resulting ulcer healed very slowly, beginning at the margin.

The slighter degrees of Röntgen dermatitis show the same microscopic features as an ordinary dermatitis. Unna alone has had an opportunity of examining microscopically a dermatitis erythematosus set up by X rays in the human skin. He found the elastin altered, and the bands of collagen swollen, whence he concludes that the Röntgen rays attack even the more resisting tissues of the skin. He thereby explains their cumulative action.

The pathological alteration set up by the rays has been ascribed to various factors. Many attribute it to a chemical action of the ultra-violet rays, others to a corrosive action of glowing platina molecules torn from the electrodes and hurled into the substance of the skin. Others again account for it by the influence of the electric current, or of waves radiating from the induction coil, whilst Tesla attributes it to the action of ozone, which is formed in great quantities in the neighbourhood of large coils.

According to Jutassy,† the biological influence is set up by

* *Fortschritte*, vol. ii., p. 128.

† *Ibid.*, p. 118.

unknown constituents of the Röntgen rays. For the recognition and identification of these we must wait until the optical theory of the X rays has been more fully developed.

Kümmel* is of opinion that the healing is due to a destruction or burning of the skin, as in other methods of cauterization, although for successful treatment it is unnecessary to set up a deep artificial dermatitis.

Albers-Schönberg† recognises a direct influence of the rays, especially on tubercular tissue, which action is increased by the resulting hyperæmia.

Grumnach‡ considers it as not a specific, but a general reaction—that is to say, an electro-chemical action aided by light and warmth.

Gassmann and Schenkel§ believe that the action is directly due to the Röntgen rays themselves. Rieder, Corol, Forster, and Kienböck agree with them that the X rays are the real agents of the treatment, and we ourselves, as a result of the earliest observations,|| formerly considered that the physiological effects were not due to an ordinary discharge, but to a genuine radiation, probably identical with the X rays.

Since then, however, in consequence of Freund's researches, we have become convinced that the silent discharge of static electricity collected on the tube plays an important rôle in its action on the skin.

Freund experimented on the physiological effects of the direct spark discharge, of the silent discharges, and of other invisible radiations, and as the result of a comprehensive investigation came to the following conclusions:

1. The direct spark discharge, from whatever source it originates, whether from a direct spark inductorium or as radiation from the apparatus of D'Arsonval and Oudin, will cause shedding of the hair in animals.

2. The direct spark discharge checks the development of, and finally destroys, the pathogenetic bacteria in culture media.

3. The action of the direct spark discharge is increased by the earthing of the exposed object, by a prolongation of the exposure, by approaching the electrode, by an increased velocity of inter-

* Hamburg, XXVII. Kongress der Deutsch. Gesellsch. für Chirurgie, 1898.

† *Fortschritte*, vol. i., p. 72.

‡ *Deutsche med. Wochenschrift*, 1899.

§ *Fortschritte*, vol. ii., p. 128.

|| *W. med. Wochenschrift*, 1897.

ruption in the primary current, and by an increase of the intensity.

4. The action shows itself through thin sheets of paper, wood, aluminium, tinfoil, and human skin.

5. It extends itself to micro-organisms suspended in fluid.

6. The physiological action of the negative spark discharge is more intense than that of the positive. On the other hand, it is effective over a smaller area. Since it was impracticable to use the direct spark discharge clinically, Freund constructed an apparatus for its dispersion in silent discharge. This had a similar effect with somewhat less intensity of physiological action, and whilst lacking many of the disadvantages, such as pain, etc., increased the sphere of action.

7. According to these experiments the Röntgen rays themselves have no physiological action.

8. Becquerel rays and phosphorescent rays have no physiological action.

9. The pathological alterations set up by the direct spark discharge are extravasations of blood in the cutis, inflammation, and an affection of the vessels of the skin characterized by the formation of vacuoles.

Schall, Leonard, Bordier, Salvador, Gocht and others agree with this theory that the X rays themselves have no physiological action on the skin, but that the effect is due to electrical discharges.

Apostoli* ascribes it to an electrical stream of high tension issuing from the Crookes tube.

Oudin, Barthélemy, and Darier† conclude that the changes in the skin are not caused by a local direct action of the rays on the cells of the cutis and epidermis, but that the influence is transmitted indirectly through a trophoneurotic action. This trophoneurosis, during a protracted incubation period, has its seat entirely in the central nervous system.

Destot also regards these changes as having a trophoneurotic origin. Kaposi explains them by a paresis of the bloodvessels, whilst Bordier is of opinion that they originate in a disturbance of nutrition.

On our decision between these diametrically opposed theories depends the question whether we should use the so-called 'hard' or 'soft' vacuum tubes.

* *New York Medical Journal*, October, 1897.

† *Monatschrift f. prakt. Dermatologie*, xxv.

Before entering into this question I will say a few words on the use of various vacuum tubes. In our experience we give the preference to three types of tubes. These are :

1. The Gundelach tube.
2. The Queen self-regulating ray tube of Queen and Co. of Philadelphia, or the automatic tube of Müller of Hamburg.
3. The Röntgen lamp with regulating vacuum of Siemens and Halske of Berlin.

The principle of the Gundelach tube is well known. Both the other types are constructed with regulating vacua, the regulation being effected by the use either of bodies which absorb oxygen (*e.g.*, phosphorus in the tubes of Siemens and Halske) or of substances which give off gases or moisture.

The Queen or Müller tube is made on the principle discovered by Dorn. It has a side tube containing caustic potash fused into the main tube. When the vacuum becomes too high in the main tube and its resistance is increased, sparks pass through the side tube. This heats the potash, and the moisture given off reduces the vacuum in the main tube. There is a gap in the circuit of the side tube, which can be altered at will. The tube is made 'hard' by increasing this adjustable gap. Diminishing this gap lowers the vacuum, thus making the tube 'soft.' Directly the resistance in the main tube increases above that of the adjustable gap, sparks once more pass through the side-circuit and warm the potash, thus again reducing the vacuum.

The tube of Siemens and Halske has a similar mode of regulating the vacuum. If the vacuum be too low the current is passed through a side tube containing phosphorus. The phosphorus is heated, and by absorbing some of the oxygen in the tube increases the vacuum. If the vacuum is too high, the glass of the side tube may be heated with a spirit-lamp. The gaseous particles condensed on the walls are thus set free and the vacuum reduced.

The colour of the light issuing from the tubes has no influence on the intensity of the X rays, but depends only on the composition of the glass. The glass used for Siemens' tubes contains borax. This gives the fluorescence a blue colour, whilst most other tubes, being made of Thuringen glass, emit a greenish-yellow fluorescence.

At the present day the general opinion is that Röntgen rays are not a single isolated species of radiations, but rather an aggregation of different rays, of varying absorbability and

intensity. Some of these pass easily through the soft parts of the body and are absorbed by the bones; another portion pass with equal facility through the soft parts and the bones themselves.

The former variety, which are produced by low vacuum tubes, have been designated X_1 rays. The latter variety, obtained with high vacuum tubes, are called X_3 rays, whilst those of a medium intensity are named X_2 rays. According to Lester, Leonard and Watch of Philadelphia, the formation of these different varieties of rays depends on the frequency of interruption in the Ruhmkorff coil as well as on the degree of the vacuum.

Röntgen himself divides the vacuum tubes according to the degree of exhaustion and consequent potential of discharge into ‘hard’ and ‘soft.’ Tubes with high potential of discharge are called ‘hard’ and produce X_3 rays; those of lower potential are called ‘soft’ and produce X_1 rays.

According to Professor Valenta, a tube may also be made ‘harder’ by the interposition of a spark gap or by the use of a current from Tesla’s inductorium.

In his therapeutic work, Sträter* found that a great difference is noticeable in the action of the rays on the skin according as ‘hard’ or ‘soft’ tubes are used. With ‘soft’ tubes redness and reaction set in after a few exposures, while with the ‘hard’ tubes reaction sets in much later or not at all. If we wish to influence pathological processes in the epidermis we use a soft tube, whereas to act on the deeper tissues we need one somewhat harder. Very hard tubes are quite useless for the treatment of the skin.

Although I have for some years directed my attention to the quality of the tubes, I cannot altogether agree with Sträter’s conclusion, although I must acknowledge that the condition of the tube has a considerable influence on the result. In the treatment of diseases of the skin one must always bear in mind the quality of the tube, and seek to obtain more exact information as to the relation between its hardness and the corresponding reaction of the skin.

Kienböck† agrees with the conclusions of Sträter, but in practice he distinguishes five degrees of hardness, corresponding to different grades in the exhaustion in the tubes:

* *Deutsche med. Wochenschrift*, 1900. Ref. IIahn.

† *Klin. Wochenschrift*, 1900. Referat.

1. Very hard tubes which give no Röntgen light.
2. Hard tubes producing a bright image on the screen with but little contrast.
3. Medium hard tubes giving a well-contrasted image on the screen.
4. Soft tubes rich in Röntgen rays of slight penetration.
5. Very soft tubes giving no Röntgen light.

With regard to the different varieties of Röntgen rays he comes to the following conclusions: The greater the number of the X rays and the less their penetration, the stronger is their action, whether on fluorescent screen, photographic plate or the living skin. For a tube to act powerfully, it must have a suitable vacuum—*i.e.*, be 'soft' enough to give a well-contrasted image of the hand on the screen.

Hard tubes—*i.e.*, tubes with too high a vacuum—oppose too great a resistance to the current. They thus compel the current to pass round the outside of the tube, and the greater portion of the electricity passes into the surrounding medium, more especially into the skin itself. In this case only a small amount of Röntgen rays of slight penetration is produced. A very 'hard' tube is, in Kienböck's opinion, almost useless for diagnostic or therapeutic purposes. The adjustable tubes are far superior to the ordinary ones.

Kienböck reports further that in four separate cases he had exposed the patient for a considerable period to the action of 'hard' tubes, without any apparent effect. He then had recourse to 'soft' tubes, and in a very short time visible clinical symptoms were produced. He concludes from these observations that the soft tubes alone are efficacious.

Kienböck overlooks however the cumulative action of the X rays. Probably, if he had not changed from hard to soft tubes, the symptoms would have appeared after the same interval, since the hard tubes require just as long to set up a reaction as do the soft ones. We ourselves now always work with the same hard tubes, and with them have produced the good results we have published.

Albers - Schönberg* uses the improved Walter's tube with regenerator and water cooling, designed by Müller of Hamburg. He distinguishes four degrees of hardness:

1. Hard, giving a gray image of the bones of the hand on the screen.

* *Fortschritte*, vol. iii., p. 140.

2. Medium soft, giving a grayish-black image.
3. Soft, giving a deep-black image.
4. Very soft.

In conclusion, I must acknowledge that the statements of Kienböck and Sträter are partially correct. After repeating their experiments, I found that soft tubes are indeed more rapid and powerful in their effects. Nevertheless, I must continue to recommend hard tubes for therapeutic purposes, since the soft tubes are apt to set up sudden and unforeseen inflammatory reactions. This I have proved again and again, when I have followed Kienböck's procedure. Kienböck's so-called 'good' tubes, after a few exposures, often set up deep excoriations, which healed very slowly, whilst with our own method no such unpleasant results occurred.

Another point of importance is the choice of a suitable distance of the tube from the patient.* A novice in the treatment should begin with from ten to twelve inches, whereas an expert may prefer from two to eight inches. The action at the shorter distance is noticeably more intense and rapid. It is, therefore, especially important to watch the case most carefully, in order not to overlook the commencement of reaction.

A necessary precaution is the careful shielding of parts which we do not wish to expose to the rays. If this is neglected we may get reaction with dermatitis and loss of hair in adjacent parts. Albers-Schönberg uses tinfoil pasted on paper or cardboard, the breast and throat being shielded by a serviette of the same material. We make use of masks made out of thick cardboard, covered with lead-foil half a millimetre in thickness, the mask projecting at least four inches over the edge of the hair on the forehead and temples. Openings are made in this mask for mouth and nostrils.

The duration of the daily exposure varies in different cases. By a preliminary sitting we make sure that the patient has no idiosyncrasy or abnormal reaction of the skin. We then proceed with exposures gradually increasing from five to twenty minutes in length.

Albers-Schönberg never gives more than ten minutes' exposure on the first and second days. If the skin remains normal, he then lengthens the sittings, half an hour being the maximum length allowed. Longer exposures than this are to be absolutely avoided.

* *Fortschritte*. vol. ii., p. 140.

Let us now consider the momentous question, What is the true agent in radio-therapy, and what action have the Röntgen rays on bacteria? In order to determine the connecting link between a physical force and a physiological effect, we must first ascertain whether the force in question is isolated, or whether the effects are due to other forces accompanying it.

Since the X rays are accompanied by a series of radiations with different physical properties, we must take precautions to guard the exposed object from any action other than that of the isolated Röntgen rays.

Kienböck,* as the result of many experiments, has come to the conclusion that the true factor is the Röntgen light itself. He proves that the effect varies with the quantity of the Röntgen rays entering the skin. Their quality or penetrating power also affects the result. He assumes that the influence on the skin corresponds to that on the fluorescent screen or photographic plate, and therefore, since the action on the photographic plate is a chemical one, he considers that the dermatitis set up by the X rays depends on a chemical alteration of the tissue.

In my own opinion, the action of radio-therapy depends rather on the invisible silent discharges from the surface of the vacuum tube. Various conditions influence the quality and intensity of these discharges. Doubtless, one of these is the degree of exhaustion of the tube. The other conditions are the quantity and potential of the current, the frequency of the interruption, the size and construction of the coil, and lastly the size and form of the vacuum tube itself. We must, however, concede that the Röntgen rays play a certain rôle, although perhaps only a secondary one. Like many other rays, they have the property of promptly discharging bodies laden with static electricity. The Röntgen tubes themselves are such charged bodies, and perhaps the facility and regularity of the electrical discharge from their surface may be modified by the X rays.

This question has not as yet been finally determined, and further investigation is necessary.

As has already been stated, Freund undertook a series of experiments on the physiological effects of the direct spark discharge. These were carried on in the Pathological Institute of Vienna and in my Institute for Radiography and Radio-therapy. He completely demonstrated its deleterious action on the growth of bacteria and its power of causing epilation.

* *Klin. Wochenschrift*, 1900.

The spark discharge then can set up actions which hitherto have been ascribed exclusively to the Röntgen rays. By means of Freund's method I have myself destroyed the hair of my left forearm on a patch of skin the size of half a crown. Moreover, Freund has proved by further experiments that the Röntgen rays themselves, when properly isolated, have no apparent influence on the growth of bacteria.

This brings us to the consideration of the bactericidal action of the Röntgen rays. The results of investigation on this point are strangely contradictory.

Whilst Lortel and Genoud,* Fiorentini and Linaschi,† report an arrest of development in the tubercular bacilli of the guinea-pig, Mühsam‡ finds that the general tuberculosis in the guinea-pig is not affected by the Röntgen rays, whilst to a certain extent a local tuberculosis is hindered in its development.

Sormani§ exposed numerous cultures of bacteria for six hours to the Röntgen rays at a distance of from one to two inches. He found no alteration in the rapidity or mode of development, in the formation of gas, or in their colour, fluorescence, or virulence.

Mink,|| Wittlin, Beck and Schulz, Berton, Sabracès and Rivière, Brunton, Blaikie, Pott, Wolff, Grumnach, and others, have made experiments on various bacteria with negative results. Schaudinn¶ has made experiments on various types of unicellular organisms, and shows that the protozoa differ greatly in their reaction to the Röntgen rays. The effects of the rays are as manifold as are the form and life-conditions of the protozoa themselves. These differences depend possibly on the different conditions of the nuclei, and on the presence or absence of capsules.

* 'Tuberculose expérimentale atténuée par la radiation Roentgen.' *Comptes Rendues*, 1896.

† Cited by Rouland, 'Report on the Application of the New Photography,' etc., *British Medical Journal*, 1897.

‡ *Freie Vereinigung d. Chir.*, Berlin, 1898.

§ *Giorno della V. soc. et dig.*, 1896.

|| Mink, 'Zur Frage über die Einwirkung der R. Strahlen auf Bakterien,' u.s.w., *Münchener med. Wochenschrift*, 1896, No. 5, and 1898, No. 9; Wittlin, *Centralblatt für Bakteriologie*, ii., p. 676; Beck and Schulz, *Zeitschrift für Hygiene*, 1896, xxiii., p. 490; Berton, 'Action des radiation de Röntgen sur le bacille diphter.,' *Semaine Médicale*, 1896, p. 283; Wolff, *Sitzung der Berl. med. Gesellschaft*, March 2; Blaikie, *The Lancet*, 1898, ii., p. 1425; Sabracès and Rivière, 'Recherches sur l'action biol. des rayon X,' *Comptes Rendues*, 1897, 44, No. 18,979; Grumnach, *Deutsche med. Wochenschrift*, 1899.

¶ *Pflüger's Archiv. f. d. ges. Physiologie*, 1899.

The results obtained by Rieder* in his experiments on various micro-organisms were essentially different. He used the Volt-ohm tubes and a coil giving a twelve-inch spark. The distance of the antikathode from the cultures was four inches, and they were exposed to the Röntgen rays for from one to three hours. The cultures were covered by a leaden plate having a central aperture, so that the exposed part might be directly compared with the unexposed portion. An agar plate culture of cholera vibrio was next exposed to the rays for forty-five minutes. It was then placed in an incubator kept at a temperature of 37° C. together with a control culture plate which had not been so exposed. On the exposed plate the colonies were markedly fewer in number than on the other. Similar experiments were made with gelatine cultures of bacterium coli, staphylococcus pyogenes aureus, streptococcus, dibacillus, typhus, and the bacilli of anthrax. The bacilli of tubercle in meat extract, glycerine, and solution of peptone were similarly affected.

In consequence of the bactericidal action of the Röntgen rays on plate cultures, Rieder† made further experiments on animals. Mice, rabbits, and guinea-pigs were inoculated with the bacilli of anthrax, streptococcus, and staphylococcus, and directly after the injection they were exposed to the Röntgen rays. The results were negative, and Rieder comes to the conclusion that the rays have no effect on acute infectious processes.

In order to study its action in chronic affections, Rieder experimented on animals infected with tubercular bacilli. After exposure to the rays, necrotic destruction of the skin was noticed. This came on very gradually, remained for a considerable period unaltered, and showed but little tendency to extend. The affected skin was covered with scabs, swelling and encapsulation of the tubercular foci was also observed. In the control cases the skin showed ulcers as if made by a cautery, and these had a great tendency to increase in area. Disease of the internal organs set in later in those animals which had been exposed to the rays.

The local tuberculosis was arrested by the rays, and in many cases the general infection was retarded, but in spite of this, all the animals succumbed.

No encouraging results followed the treatment by Röntgen-therapy of those suffering from chronic tuberculosis of the lungs.

* *Münch. med. Wochenschrift*, 1898, i., p. 203, referred to by Hahn.

† *Münch. med. Wochenschrift*, 1899.

Wolfenden and Forbes Ross* have added greatly to our knowledge by their experiments on the influence of the Röntgen rays on bacteria. They have experimented with cress-seed, yeast, and twelve different sorts of bacteria and cocci. They conducted their researches with extraordinary critical and sceptical skill. They recognise seven possible factors which alone or together may produce a retarding or stimulating influence on the growth of bacteria. These are :

1. The X rays themselves.
2. The cathode rays.
3. The disturbance in the electrical field.
4. The production of ozone or other atmospheric changes.
5. Rise of temperature.
6. Chemical or other alterations in the culture medium.
7. Rays of ordinary light proceeding from the tube.

Their results are summed up as follows :

‘It is impossible to hinder the growth of bacilli or cocci by exposure to the Röntgen rays. Such a result would be in direct opposition to the fact that the germinating power of seeds is increased by such exposure, and that, moreover, the processes of fermentation are quickened. The Röntgen rays have a similar stimulating effect on the lower micro-organisms, such as bacilli. This shows itself in an unfailing alteration in their biological and physiological characteristics—the appearance, length, and thickness of the bacteria; their mode of grouping and spore formation is completely altered. When destruction of bacteria occurs in the exposed cultures it is due to exhaustion consequent on excessive growth, rendering further development impossible. These observations apply more especially to tubercular bacilli, which undergo great alterations on exposure to the rays. They become thick, short, transparent, homogeneous rods which look more like anthrax or coli bacilli. They are uniformly coloured, showing no trace of punctation. They appear to form spores or pseudo-spores. Among them are seen a number of unaltered tubercular bacilli of normal appearance. The Röntgen light has thus no direct bactericidal action.’

On what then does the good result of Röntgen-therapy on lupus depend? Is it due, after all, to a direct action of the rays on the bacilli themselves, or is it solely due to an action on the skin tissues of the patient, setting up a form of necrosis which

* ‘The Effects produced in Cultures of Micro-organisms,’ etc., *Archives of the Röntgen Ray*, vol. v., 1900. Referred to in *Fortschritte*, vol. iv.

alters the nutrition of the bacilli? This question marks the present position of our knowledge of the therapy of the Röntgen ray, and points out the line of future research.

If we now look back on the progress we have made, we are forced to ask, What have we accomplished, and what is the aim for which we strive?

We have succeeded in curing a number of diseases of the skin by means of a physical agent (the Röntgen rays), and the problem now is to discover if this agent is indeed the Röntgen rays themselves, or if the result is due to other factors of a physical or chemical nature. Our next task will be to experiment with each separate physical factor of the many which are generated by the complicated apparatus we employ for the production of the X rays, to isolate each completely, and to discover its individual properties and mode of action.

THE END